



Small Wind Technology

Trudy Forsyth – NREL/NWTC

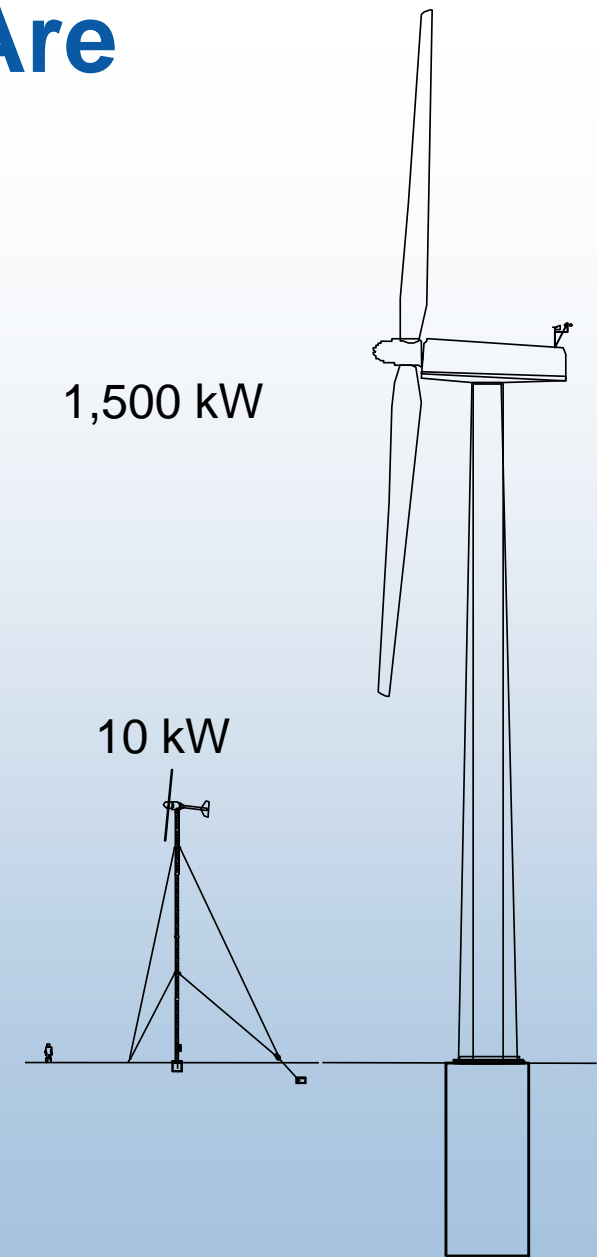
May 20, 2009

Outline

- Small Wind vs. Large Wind
- DOE/NREL Public/Private partnerships
- DOE/NREL Independent Testing
- US Residential Wind policies
- Other DOE/NREL Distributed Wind activities

Small Wind Turbines Are Different

- **Utility-Scale Wind Power**
600 - 1,800 kW wind turbines
 - Installed on wind farms, 10 – 300 MW
 - Professional maintenance crews
 - 13 mph (6 m/s) average wind speed
- **Small Wind Power**
300 W - 100 kW wind turbines
 - Installed at individual homes, farms, businesses, schools, etc.
 - On the “customer side” of the meter, or off the utility grid entirely
 - High reliability, low maintenance
 - 9 mph (4 m/s) average wind speed



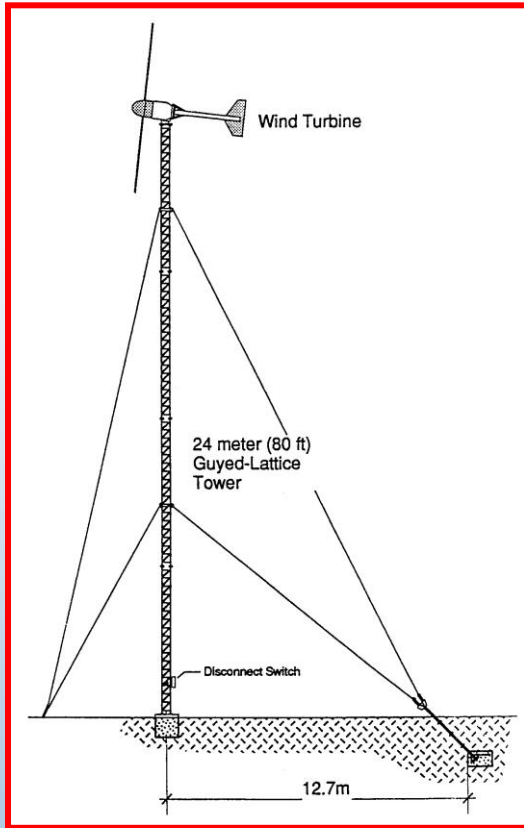
Small Wind Turbines

- **Configuration:** 2 or 3 blades aimed into the wind by the tail
- **Blades:** Fiber-reinforced plastics
- **Over-Speed Protection:** Furling (rotor turns out of the wind), no brakes
- **Generator:** Direct-drive, permanent magnet alternator (no brushes), 3-phase AC, variable-speed operation
- **Controller:** Electronic device that delivers
 - DC power for charging batteries
 - AC power for utility interconnection
- **Result:**
 - Simple, rugged design
 - Only 2–4 moving parts
 - Little regular maintenance required

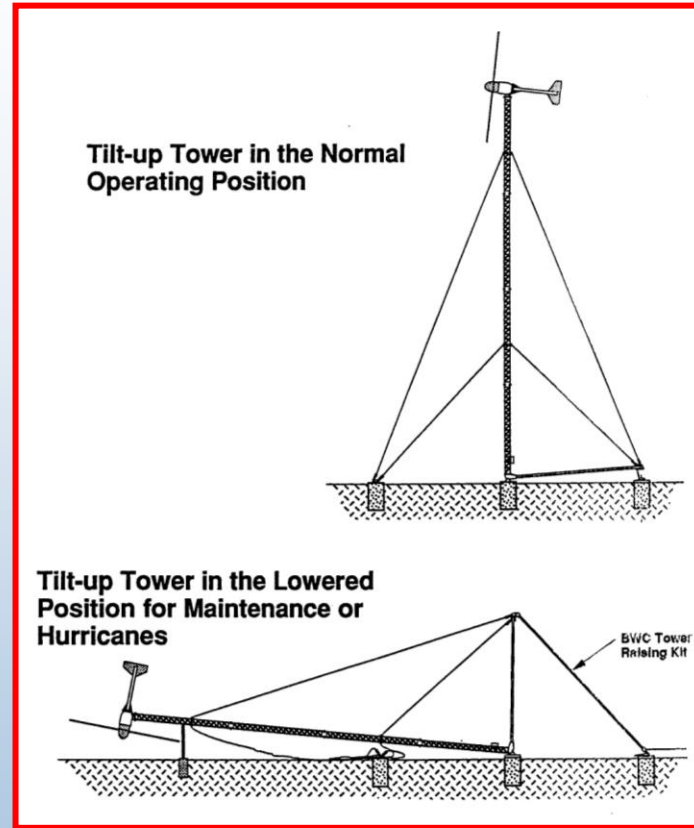


Bergey EXCEL, 10 kW

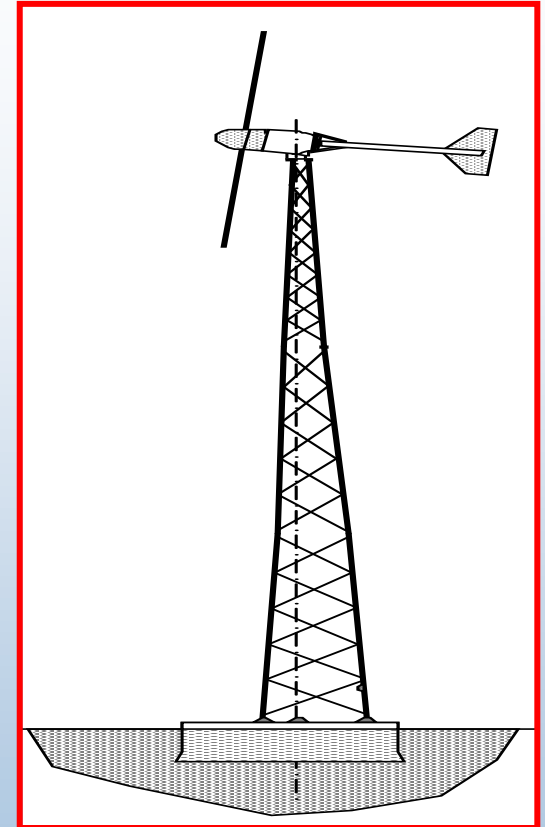
Small Wind Turbine Towers



Guyed Tower



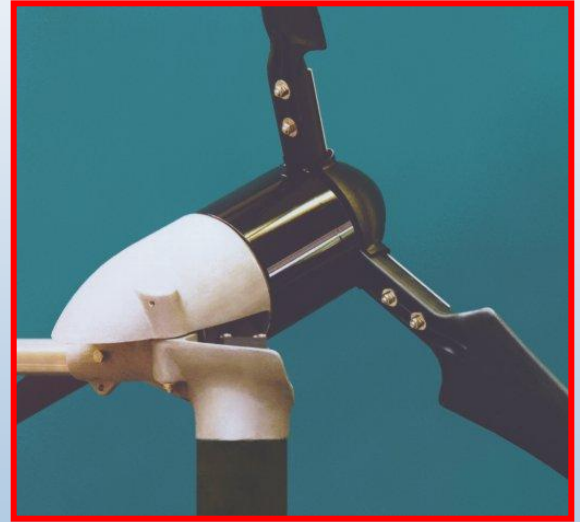
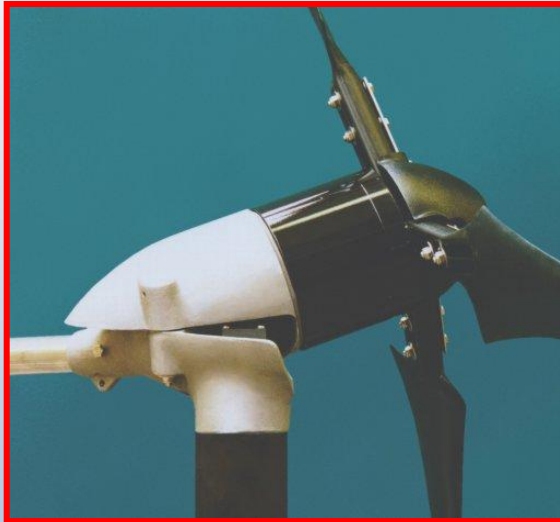
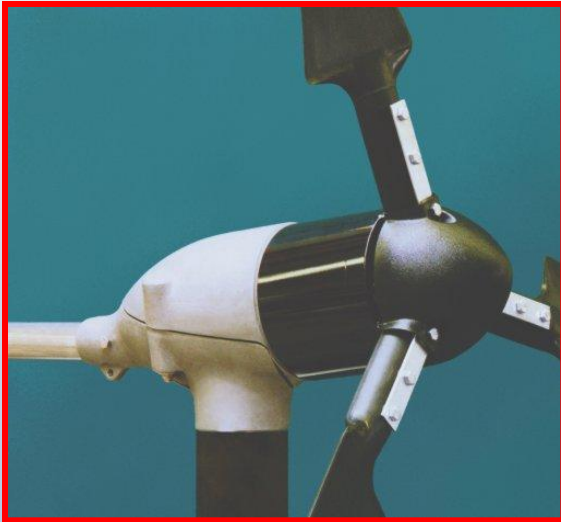
Tilt-Up Tower



Self-Supporting
Tower

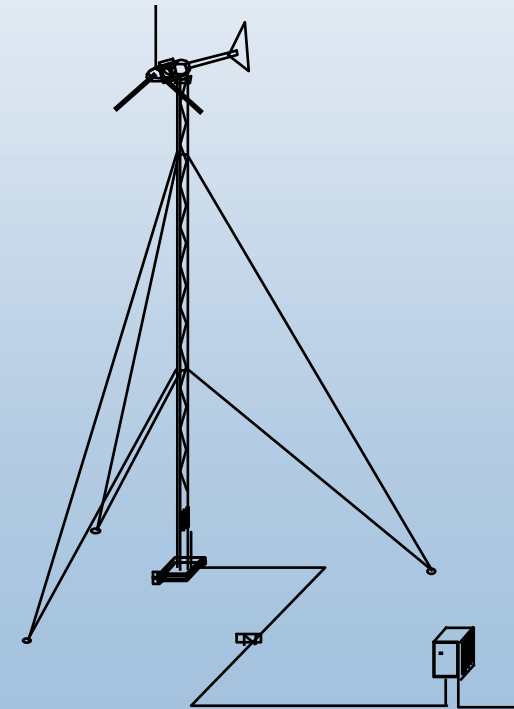
Over-Speed Protection During High Winds

- Angle Governor: The rotor turns up and to one side



The Wind Turbine Controller

- Battery-Charging
 - Converts AC power to DC for charging batteries
 - Regulates the battery voltage to prevent overcharging
- When the battery is fully charged:
 - Power is diverted to another load, or
 - The rotor is unloaded and allowed to “freewheel”
- Grid Interconnection
 - “Inverter” converts the power to constant frequency 60 Hz AC
- UL label may be required



Technology Trends

- Advanced blade manufacturing methods
- Rare earth permanent magnets
- Grid-connected inverters
- Induction generators
- Design for low wind speeds
- Alternatives to furling for rotor speed control
- Reduced rotor speeds → reduced noise
- Design standard

Maintenance, Warranty, and Lifetime

- “Low Maintenance” not “No Maintenance”
 - Inspection and maintenance every 1-2 years
 - Inspect mechanical and electrical connections, check for corrosion, check guy wire tension, inspect/replace leading-edge tape, etc.
 - Beyond 10 years: blade or bearing replacement may be needed
- Warranties
 - 2-5 years, coverage of materials and workmanship
- Lifetimes of 15 to 30 years with regular maintenance

“A wind turbine will see as many operating hours in one year as an automobile will see in 200,000 miles!”

NWTC Industry Partnership:

Endurance Wind Power www.endurancepower.com

- Endurance S-250 wind turbine
 - 5 kW, 5.5-m rotor, constant-speed with induction generator & gearbox
- IEC-compliant testing
 - Power performance, acoustics, safety & function, and duration (2,500 hours)
- Windward Engineering teamed with outside investors/business experts to form Endurance Wind Power in 2007



NWTC Industry Partnership:

Southwest Windpower

www.skystreamenergy.com

- Skystream 3.7 wind turbines
 - 1.9 kW, 3.7-m rotor, direct-drive with power convertor integrated into the nacelle
- Control software development & refinement
- Obtaining data needed for certification to IEC 61400-02
 - SWWP has received IEC certification through Germanischer Lloyd
- Southwest Windpower has received >\$20M in venture capital investment, 2004 - 2007



NWTC Industry Partnership:

Northern Power Systems www.northernpower.com

- Prototype of new generation NW100 wind turbine
 - 21-m rotor w/36-m “soft” tower
 - Direct-drive with power convertor integrated into the nacelle
- Measurements have included:
 - Modal frequencies, tower and rotor loads, power performance, acoustics, & power quality
- Northern Power received a commitment from a venture capital partner, June 2008



Purpose of NREL's Independent Testing

- To help industry provide consumers with more certified Small Wind Turbine (SWT) systems, DOE/NREL launched a SWT system Independent Testing project in 2007
- Test turbines to recently developed International Electrotechnical Commission (IEC) and American Wind Energy Association (AWEA) standards
- Test data can be used by manufacturers to present to the Small Wind Certification Council (SWCC), a nonprofit organization with support from DOE, AWEA, state energy offices, and turbine manufacturers, for North American certification

Purpose of IT (cont.)

- Test data can also be submitted to A2LA as partial input for international certification
- SWTs that are tested and certified will give consumers greater confidence that the systems they install will perform within specified wind regimes as advertised by the manufacturer

Small Wind Turbine Systems Selected

Through a competitive solicitation, NREL selected four commercially available SWT systems to test in 2008/2009. Turbines selected include:

- Abundant Renewable Energy ARE 442
- Entegritty Wind Systems EW15
- Gaia-Wind 11kW
- Mariah Power Windspire

ARE 442

www.abundantre.com

- 10kW
- 3-bladed horizontal-axis upwind turbine
- Hub height: 30.9 meters
- Rotor diameter: 7.2 meters
- Three-phase permanent-magnet generator
- Operates at variable voltages up to 410 volts AC
- Installed at the NWTC 6/08



Entegry EW15

www.entegrywind.com



- 50kW
- 3-bladed horizontal-axis downwind turbine
- Hub height: 30.5 meters
- Rotor diameter: 15 meters
- Three-phase induction generator
- Operates at 480 volts AC
- Scheduled for installation at NWTC 1/09

Gaia-Wind 11kW

www.gaia-wind.com



- 11kW
- Twin-bladed downwind
- Tower: 18 meters tall
- Rotor diameter: 13 meters
- Three-phase induction generator
- Operates at 480 volts
- Installed at NWTC week of May 5th

Mariah Power Windspire

www.mariahpower.com

- 1.2kW
- Vertical-axis Giromill wind turbine
- Tower is 9.1 meters tall
- Rotor area is 1.2 x 6.1 meters
- Single-phase permanent-magnet generator
- Operates at 120 volts AC
- Installed at NWTC 3/08 w/out inverter
- Commissioned on May 7th



IEC Testing per Independent Testing Project

Tests, performed to IEC standards and in compliance with A2LA requirements, will include:

- Duration
 - 61400-2, 2500 hours of run time with high wind requirements
- Power performance
 - 61400-12-1 referencing Appendix H for small turbines
- Acoustic noise emissions
 - 61400-11
- Safety and function
 - 61400-2
- Power quality (for 3-phase only)
 - 61400-21

Draft AWEA standard is a subset of 61400-2, -11, and -12

NREL's IT Web Site

For progress on DOE/NREL's Independent Testing project, go to NREL's web page under a section titled Small Wind Turbine Independent Testing that can be found at:

http://nrel.gov/wind/technical_support.html

National Renewable
Energy Laboratory:
www.windpoweringamerica.gov

American Wind Energy
Association:
www.awea.org

Market overview:
“Wind Turbine Buyers Guide”
Home Power Magazine, #119,
June & July 2007
<http://www.homepower.com/files/featured/TurbineBuyersGuide.pdf>

Small Wind Electric Systems

A U.S. Consumer's Guide



U.S. Department of Energy



Distributed Wind Power for Home, Farm, Business, & Schools



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